# Dyeing of Cotton Fabric with Natural Dye Extracted from Egyptian Cotton Leaves

**Yasser A. Abd-El-Baset[1]*, Alaa Heikal[2], Salah M. Saleh[1]**

[1]Cotton Research Institute, ARC, Textile Chemistry Dept. Giza, Egypt
[2]Department of Plant Biotechnology, Biotechnology and Genetic
Engineering Division, NRC, Cairo, Egypt

**ABSTRACT:** Cotton leaves have been used to extract natural dye for dyeing of Egyptian cotton variety Giza 86 fabric and its blend with polyester 50:50, using different mordants such as iron (II) sulfate, copper (II) sulfate, and alum. The exhaust dyeing method was utilized using the pre-mordant technique. It is observed that both fabric samples can be dyed in different colors and depth of shades with Cotton leaves dye. Iron (II) sulfate ensures the best light fastness. Improved light fastness is obtained using abovementioned lower amounts of iron (II) sulfate and copper (II) sulfate. Alum is found to be less effective than iron (II) sulfate and copper (II) sulfate on the light fastness. As a novel alternative and potential natural dye, Cotton leaves extract solution can be used to get various colors and shades with satisfactory fastness properties. The mordanted and un-mordanted fabric samples were tested for their dyeing performance in terms of color parameters K/S, (L*), a*, b*, (C*) and (H*), and fastness properties (wash, perspiration, light and rubbing fastness) were studied. The samples showed high color strength, and high fastness properties. These results are very important for industrial application and with the production of a natural dye as an inexpensive source from cotton leaves as a by-product. Another objective is to increase the production of eco-textile garments with a good price for the Egyptian customers.

**KEYWORDS:** cotton leaves, natural dye, cotton fabric, Dyeing and Egyptian cotton..

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## INTRODUCTION

Cotton is one of the foremost important crops for humanity. It's placed among the highest ten most generally grown crops within the world albeit its main purpose isn't food. Additionally to the appreciation for its fibers, cultures learned to use the entire plant for several uses, from controlling reproduction and pharmaceuticals to pigments and cattle feed. Cotton by-products have provided producers with additional value, mainly within the sort of livestock feed supplements and soil amendments [1]. The dye is that the substance that imparts color to things likes textiles, wood, and plastics. The uses of plant-based dyes are the oldest skill employed by most of the traditional civilizations to exact their emotions, celebrate festivals and paint the glory of their kings and queens. Egyptian people use plant origin dyes like madder, indigo, saffron, Curcuma, and pomegranate rind for the coloration of textiles. Tyrian purple and therefore the Kermes dyes were customarily used animal origin dyes within the fifth century [2]. Our previous work acknowledged that the start of the new millennium is certain to cause any drastic changes within the lifetime of mankind. One among them goes to be the shift towards natural dyes and their efficient usage compared to an artificial counterpart who has been slowly losing, mainly thanks to international awareness of environmental and ecology preservation [3].

Uses of organic wastes as natural dyes on textiles have been just one of the consequences of increased environmental awareness [4]. Natural dyes are less toxic, non-pollutant, less health hazard, very brilliant, rare color idea, and allergic reactions, exhibit better biodegradability and generally have higher compatibility with the environment [5].

The extract of cotton leaves is rich in tannins and flavonoids-like phytochemicals. These compounds work as a great chronic wound healer for diabetic and immune-suppressed patients by decreasing the glucose level in the body [6]. Furthermore, it has hydroxyl proline content, which boosts the collagen synthesis in the body, thereby speeding up the healing process [6].

Cotton leaves have natural constituents such as alkaloids, flavonoids, and phenolic compounds along with tannins. These constituents have a hypoglycemic effect that could be a better alternative in the management of diabetes mellitus. The hydro alcoholic extract of the cotton

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**Corresponding Author: dryassersalam@yahoo.com*

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is potentially rich in antioxidants [7].This reduces the damage caused by the free radicals by inhibiting oxidative stress, due to its natural antioxidant components [8].

Essential oil made with cotton leaves has some major components, namely tricyclene, isoleucine, bornyl acetate, α-pinene, α-terpinene, and β-pinene, of those components are responsible for the antibacterial activity against the S. aureus, Gardinella spp, E. coli, and C. Albicans bacteria [9].

The cotton leaves have anti-arthritic and anti inflammatory properties, thanks to its natural elements-like gossiping, gossypol alongside gossypetin. This prevents rheumatoid arthritis – a chronic disease that not only affects the joints but also the other parts of the body [10].

Cotton leaves have emollient properties, which soothes your headache in no time. The extract made up of cotton leaves has antiulcer and antioxidant properties that prevent gastric ulcers [10]. Every part of the cotton possesses large benefits and uses, but after reading the above benefits of cotton leaves, you'll get to know the unfamiliar benefits of cotton leaves. The main idea of this research was to use the leaves of the cotton, after harvesting the crop within the assembly of natural dyes using cheap methods to urge the dye from them and use them in dyeing cotton fabric and its blend with polyester by using conventional mordants so on supply a replacement and potential natural dye source. The main objective of this study is to produce a dye from the leaves of the cotton plant, after harvesting the fibers and to make use of these leaves, which are considered unusable waste, and to use these dyes in dyeing cotton fabrics and their mixtures with polyester and to study the stability properties of these dyes extracted from cotton leaves.

## MATERIALS AND METHODS

### Materials

The fresh leaves of cotton (Gossypiumbarbadense L.) were collected from farm of Cotton Research Institute - Agricultural Research Center (Sakha, Egypt).Unbleached long staple Egyptian cotton fabric made from Giza 86 and its blend with polyester 50:50 was purchased from Misr-El-Mehala Company for Spinning and Textile- Egypt having the following specification as shown in table 1: (MEKO) and -caprolactam are commonly used [6].

### Chemicals

All chemicals used were of analytical grade using doubly distilled water (18.5 MΩ.cm-1). NaOH was analytical grade (Koch-Light Co.), Hydrogen peroxide (30% LR grade) from Aldrich. Sodium carbonate (LR grade), sodium silicate (136 Tw, 27% $SiO_2$), the wetting agent was the commercially Triton 100 supplied by Merck. All chemicals used without purification.

### *Mordents:*

Alum, $Al_2(SO_4)_3 \cdot 12H_2O$, copper sulphate, $Cu(SO_4)_2.7H_2O$, and Ferrous sulphate, $Fe(SO_4)_2$was analytical grade (AL-Nasr Chemical Company, Egypt)

## METHODS

### *Dye extraction from cotton leaves*

One kg of wet waste leaves of green cotton leaves were air-dried under shade until its weight remained constant. Cotton leaves were then stored in black plastic bags in a dry place. About 100 g of the cotton leaves boiled in one liter distilled water and concentrated to 500 ml. the slurry was left to cool and then filtered to discard any solid material. The extracted liquor was used as the foundation of the dye.

**Table 1: specification of 100% Egyptian cotton fabric Giza 86 and its blend with polyester 50:50**

| Fabric | Plain waves | | Fabric weight $g/m^2$ | Specimens size |
|---|---|---|---|---|
| | Warp yarn/cm | Weft yarn/cm | | |
| 100% Giza 86 | 36 | 30 | 150 | 30 cm x 30 cm |
| Giza 86/polyest 50:50 | 38 | 40 | 150 | 30 cm x 30 cm |

### *Mordant treatment*

Pre-mordant treatment was carried out according to our previous work [12]. The concentration of mordents was 0.2g/l of ferrous sulphate, copper sulphate and alum. Pre-mordant was performed at goods to liquor ratio 1:40 for 30 min at room temperature. The samples were then dried in the oven at 130°C, for 5 min.

### *Dye bath process*

Exhaustion dyeing process was carried out for both cotton and its blended fabrics using IR dyeing machine at temperature 70°C, for 100 minutes , and L: R 1:40. After completion of dyeing the fabrics were washed with water and air dried.

### *Measurements and evaluation tests*

### *Color strength and color components*

To evaluate the shades obtained on dyeing cotton fabric and it's blended with extract of cotton leaves. The color strength expressed as (K/S) was measured using Perkin- Elmer double beam spectrophotometer of model Lambda 35 that is equipped with integrating sphere. The diffuse transmittance was detected at the wavelengths 400-700nm according to the Kubelka-Munk given by:

$$K/S = (1-R)^2/2R - (1-R0)^2/2R0$$

Where R is the reflectance of the colored fabric, R0 is the reflectance of the uncolored fabric, and K/S is the ratio of the absorption coefficient (K) to scattering coefficient (S); the higher the value, the greater the color strength.

The color parameters L*(lightness-darkness), a*(red-green), b*(blue-yellow component), Chroma (C) is a measure of intensity or saturation of color and Hue angle (H)

### *Fastness Tests*

### *Color fastness for washing*

This test has been conducted in accordance with ISO 105– C10: 2015 (Textiles – Tests for color fastness- Part C10: Color fastness to washing with soap or soap and soda). The dyed specimens were cut in size in 5 x 10 cm. and were washed in Launder-o-meter. A detergent solution was prepared using detergent at concentration of 5 g/l. The prepared samples were then placed in the canisters along with the 8-10 steel balls and then fixed in the launder-o-meter. These were subject to 5 cycles for approx. 20 minutes with temperature maintained at 38˚C.

### *Color fastness to light*

This test was carried out on printed samples in accordance with ISO 105-B01:2014 (Textiles – Tests for color fastness—Part B01: Color fastness to light: Daylight).

### *Color fastness for perspiration*

Color Perspiration fastness tests (acid and alkaline) were carried out according to international standard ISO 105-E04: 2018 (Textiles – Tests for color fastness – Part E04: Color fastness to perspiration).

### *Color fastness to rubbing*

This test was carried out on printed samples in accordance with ISO 105-X16:2016 (Textiles – Tests for color fastness – Part X16: Color fastness to rubbing – Small areas). For testing the dry specimen, the dyed sample was fastened to crock meter base and rubbed with white test cloth under controlled conditions for approximately 20 cycles. Similarly, for testing the wet rubbing fastness, test samples were dipped in distilled water and were squeezed between blotting papers less than 454 grams and then the entire process of dry rubbing fastness was repeated.

## RESULTS AND DISCUSSIONS

Leaf color may be a function of leaf pigment content and concentration. Pigment commonly present in cotton leaves is chlorophylls. Some pigments like carotenoids, tannins and anthocyanins are also found. Each of pigments features a unique structure and absorbs energy from different regions and at different wavelengths within the spectrum. These properties give each pigment color characteristics. For example, chlorophylls a and b absorb light within the blue and red regions while reflecting light within the green. Similarly, carotenoids are visually related to yellows and reds, tannins with browns, and anthocyanins with reds and purples.

### *Effect of mordents on Color strength K/S.*

K/S is most vital parameter to check the standard measurement of a sample in terms of depth of the color dyed fabric K/S. it's been noted from Fig. 1, that treatment of cotton fabric and its blend with copper as mordent gave a maximum K/S, which is especially attributed to the lower values of L*, thanks to the high stability formation of the complex between the Cu and chlorophylls compound. This fact could also be thanks to that chlorophylls a and b absorb light within the blue and red regions while reflecting light within the green. The results also showed that Fe metal is documented for its ability to make coordination complexes, and readily chelated with the dye. The coordination numbers of Fe is 6, so, some coordination sites are unoccupied when interact with both the functional groups of the cotton and therefore the dye. Thus, Fe metals can form a ternary complex on one site with the cotton fiber and on the opposite site with the dye. Such a robust coordination tendency enhances the interaction between the fiber and therefore the dye, leading to high dye uptake. The results are accordance with the results obtained by Bhattacharya and Shah [13].

### *Effect of mordant on color components*

The lightness (L*) values indicate the difference in luminosity between samples. The results obtained in Table 2 revealed that lightness values have been changed with the addition of mordents.

The lowest lightness values reached to 54.76, in followed by the addition of Fe 55.37 and finally with the addition alum 55.37 compared with the blank 62.27. On the other hand, the lightness (L*) values of cotton/polyester blend were 54.25, 57.15, and 60.18for Cu, Fe, and alum respectively compared with the blank 61.56.

The a* values have drastic change with Fe mordant for both cotton fabric and its blend which is reached to 1.60 and 1.76 for both cotton fabric and its blend with polyester compared with the blank 3.47, and 3.45 respectively. In the presence of alum as mordant, the fabric samples were more redness and reached to 4.47 and 4.36 followed by the fabrics treated with Cu mordant 3.58, and 3.32. The positive b* indicated that the cotton fabric and its blend tends to the yellow color.

The b* values for both cotton fabric and its blend with polyester samples with Fe mordant has the lowest value which reached to 7.51 and 7.57 and the addition of Cu as mordant for 100% cotton tends to greenish color compared with the blank 11.56 and 11.26. In the presence of alum as mordant, the fabric samples were more yellowness and reached to 13.78 and 13.28 followed by the fabrics treated with Cu mordant 10.76 and 11.26 respectively.

In the presence of Fe as mordant for both cotton fabric and its blend with polyester, the hue angle (H*) was 104 and 99 and tends to the greenish-yellow color compared to 73 and 70 degrees of the control. The hue angle degrees (H*) for both treated samples with Cu reached to 77 and 76 and for alum was 65 and 67.

The results represented in Table 2 showed that the chroma (C*), which is the saturation, or color intensity of the both fabrics were more when treated with Fe as mordant followed with Cu and alum respectively.

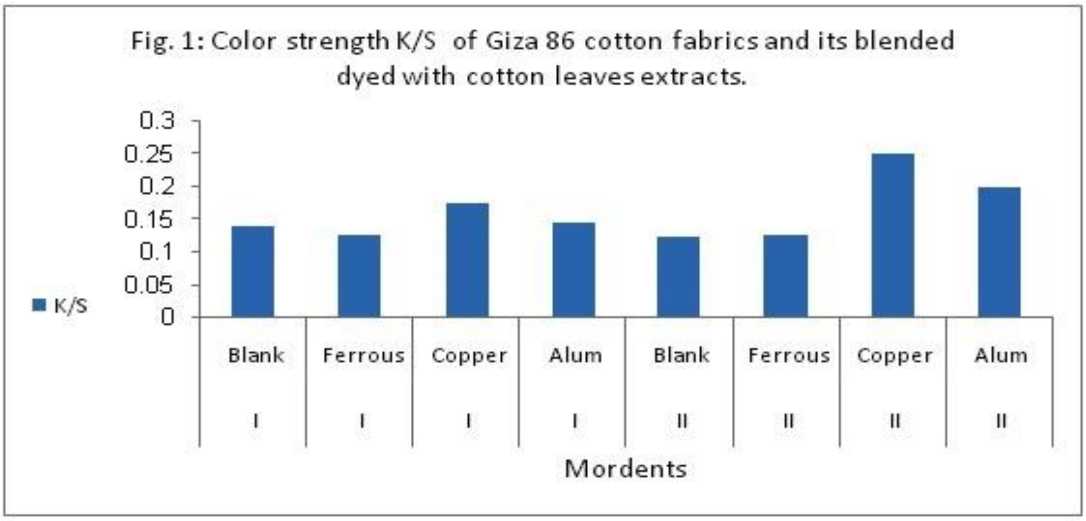

**Figure. 1 Where I is 100% cotton fabric II is cotton fabric blended with polyester 50:50**

**Table 2: Color components of Giza 86 cotton fabrics and its blended dyed with cotton leaves extracts.**

| samples | mordant | (L*) | a* | b* | (C*) | (H*) |
|---|---|---|---|---|---|---|
| I | Blank | 62.27 | 3.47 | 11.56 | 7.64 | 73 |
| I | Ferrous | 55.37 | 1.6 | 7.51 | 11.93 | 104 |
| I | Copper | 54.76 | 3.58 | 10.76 | 8.1 | 77 |
| I | Alum | 60.17 | 4.47 | 13.78 | 5.8 | 65 |
| II | Blank | 61.56 | 3.45 | 11.88 | 7.91 | 70 |
| II | Ferrous | 57.15 | 1.76 | 7.57 | 10.94 | 99 |
| II | Copper | 54.25 | 3.32 | 11.26 | 6.1 | 76 |
| II | Alum | 60.18 | 4.36 | 13.28 | 7.4 | 67 |

I and II as mentioned in Fig. 1

### *Effect of mordant on fastness properties*

The results reported in Table (3) illustrate the effect of various mordents on the fastness properties of both Egyptian cotton fabric and its blend with polyester 50:50. It is clear that both fabric samples showed an excellent light fastness improvement. This result is accordance with the investigation carried out by Fatemeh et al. [14] which indicated that the easier is the transfer of the excitation energy from the dye molecule to the fiber macromolecular. Thus, the dye –fiber bond serves as a bridge for transferring the excitation energy between the two components of the dye fiber ambient system, so, the bond promotes the energy transfer to increase the light fastness.

In Table 3,the result being assessed in the usual way in term of the grey scale values for the staining of adjacent mordant samples and change in shade as well are slightly increased in washing, rubbing and perspiration fastness among the un-mordant samples. These slightly increase may be attributed due to that the metal dye complex was mostly more stable than coloring component itself.

## CONCLUSION

The use of cotton leaves extract solution as natural waste source to dye Egyptian cotton variety of G86 and its blend with polyester fabrics has been achieved. Dyeing performance in terms of color parameter K/S, (L*), a*, b*, (C*) and (H*), and fastness properties (wash, perspiration, light and rubbing) were studied. The samples showed high color strength, and excellent light fastness and good wash, perspiration, light and rubbing properties. We believed that the results obtained here are interesting for industrial application due to the production of a natural dye as an inexpensive source of the cotton leaf as a by-product. Another objective is to contribute to solving or decrease the problem of burning cotton waste causing environmental pollution.

**Table 3: Fastness properties of Giza 86 cotton fabrics and its blended dyed with cotton leaves extracts**

| Samples | Mordents | *Washing Fastness* | | *Perspiration Fastness* | | | | *Light fastness* | | *Rubbing fastness* |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Alkaline | | Acidic | | | | |
| | | C. change | staining | C. change | staining | C. change | Staining | dry | wet | C. change |
| I | Blank | 4 | 5-Apr | 4 | 4 | 4 | 4 | 5-Apr | 4 | 6 |
| I | Ferrous | 4 | 5-Apr | 4 | 4 | 4 | 4 | 5-Apr | 4 | 6 |
| I | Copper | 4 | 5-Apr | 4 | 4 | 4 | 4 | 5-Apr | 4 | 6 |
| I | Alum | 4 | 5-Apr | 4 | 4 | 4 | 4 | 5-Apr | 4 | 6 |
| II | Blank | 4 | 5-Apr | 4 | 4 | 4 | 4 | 5-Apr | 4 | 6 |
| II | Ferrous | 4 | 5-Apr | 4 | 4 | 4 | 4 | 5-Apr | 4 | 6 |
| II | Copper | 4 | 5-Apr | 4 | 4 | 4 | 4 | 5-Apr | 4 | 6 |
| II | Alum | 4 | 5-Apr | 4 | 4 | 4 | 4 | 5-Apr | 4 | 6 |

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